A166

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G05D 9/12

A1

(11) International Publication Number: WO 97/03394

(43) International Publication Date: 30 January 1997 (30.01.97)

(21) International Application Number: PCT/GB96/01677

(22) International Filing Date: 10 July 1996 (10.07.96)

(30) Priority Data:
9514338.4 13 July 1995 (13.07.95) GB

(81) Designated States: NZ, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

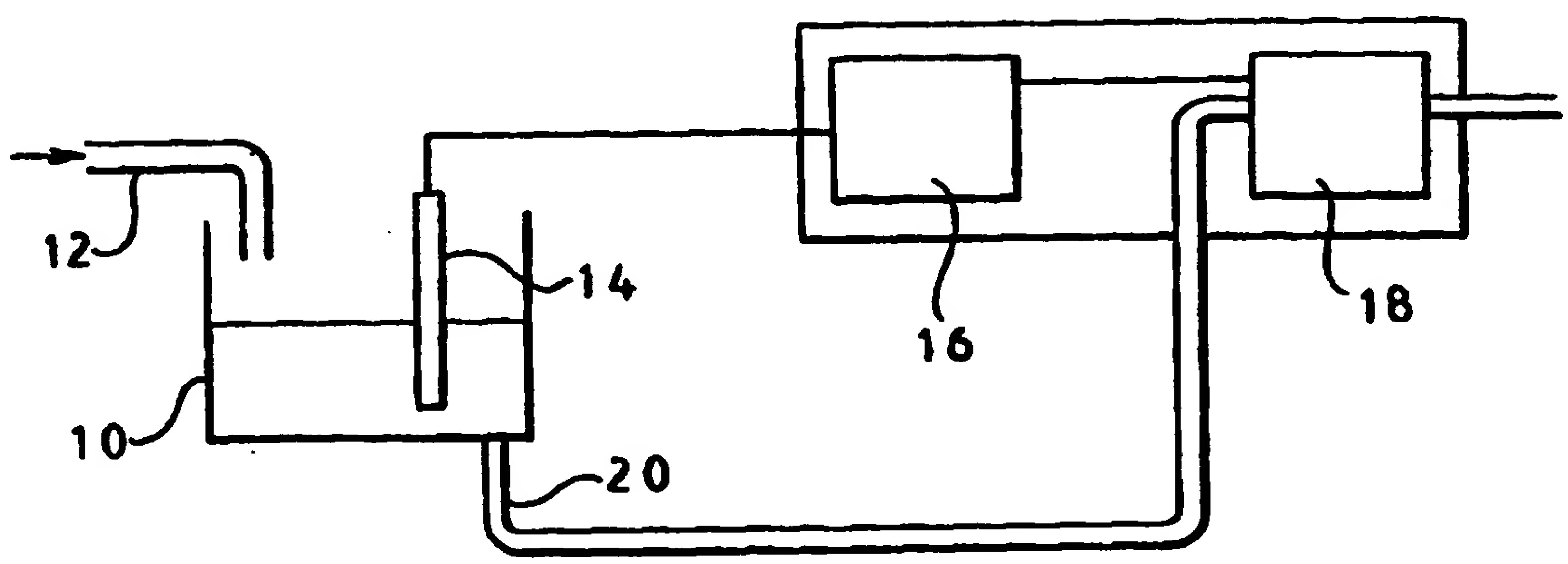
Published
With international search report.

(71) Applicant: ITT INDUSTRIES LIMITED [GB/GB]; Jays Close, Viables Industrial Estate, Basingstoke, Hampshire RG22 4DW (GB).

(72) Inventors: KEMP, William, Harry; lot 20, Concession 11, Township of Lanark, Clayton, Ontario K0A 1P0 (CA). SHIDELER, Victor, Joseph; 489 Bridge Street, Carleton Place, Ontario K7C 3JS (CA).

(74) Agent: VAUFROUARD, John, Charles; Elkington and Fife, Prospect House, 8 Pembroke Road, Sevenoaks, Kent TN13 1XR (GB).

(54) Title: LIQUID LEVEL CONTROL SYSTEM



(57) Abstract

A liquid level control system comprises a container (10) for receiving a flow of liquid. Level sensing means (14) is arranged to provide a control signal which is variable in dependence upon the depth of liquid in the container. A pump (18) is coupled with an outlet (20) from the container and is responsive to the control signal to expel liquid from the container at a rate which increases as a function of increase of liquid depth.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SG	Singapore
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LR	Liberia	SZ	Swaziland
CS	Czechoslovakia	LT	Lithuania	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	LV	Latvia	TJ	Tajikistan
DK	Denmark	MC	Monaco	TT	Trinidad and Tobago
EE	Estonia	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	UG	Uganda
FI	Finland	ML	Mali	US	United States of America
FR	France	MN	Mongolia	UZ	Uzbekistan
GA	Gabon	MR	Mauritania	VN	Viet Nam

LIQUID LEVEL CONTROL SYSTEM

This invention relates to a liquid level control system and more particularly but not solely to such a system for controlling the level of milk in a tank of a milking machine.

Currently, milk is extracted from cows utilising a vacuum pressure system and receiver tank. When milk reaches a given level in the receiver tank, a pump is activated which pumps the warm milk from the receiver through a heat exchanger into a bulk refrigerated storage tank. The stored milk is then extracted by a pump located in a milk tanker truck for delivery to the processing plant.

Milk is a fragile material, containing a high fat/solids content. If the milk is pumped from the receiver tank too quickly by a standard centrifugal pump, the fat in the milk is separated and overall quality/value of the milk is decreased.

Further, if the milk is pumped too quickly through the heat exchanger, proper cooling of the milk is inhibited and refrigeration costs in the bulk storage tank are increased unnecessarily.

There is for this application a need to ensure that the receiver tank is not overfilled, during receipt of variable flows of milk, and to transfer the milk as slowly as possible through the heat exchanger. This invention has been arrived at by a consideration of these requirements and has resulted in a liquid level control system which can be used in a milking machine but which is suitable for use in any application where the transfer of liquid from a receiving tank container is required.

According to the invention there is provided a liquid level control system, comprising a container for receiving a flow of liquid, level sensing means for providing a control signal variable in dependence upon the depth of liquid in the container and a pump coupled with an outlet from the container and responsive to the control

signal for expelling liquid from the container at a rate which varies as a function of the liquid depth.

The pump may be an impeller pump and the impeller may be flexible.

The pump may be driven by an electric motor at a speed which is variable in dependence upon the control signal to vary the rate at which liquid is expelled. The electric motor may be an AC induction motor. The induction motor may be powered by an inverter which provides a supply voltage and frequency, dependent upon the control signal, which is a function of liquid depth.

The induction motor may be powered by a power supply having an inverter and as described and claimed in US Patent Application Number 08/291,239 of the present inventor.

The system may include means for providing a control signal at switch on to run the motor at high speed for a predetermined time interval thereby to prime the pump.

The level sensing means may comprise a pair of spaced conductive probes extending downwardly or upwardly side by side in the container and wherein the resistance between the probes which varies as a function of liquid depth is employed to provide the control signal. A further conductive probe of length shorter than said pair of conductive probes may be provided extending downwardly alongside the pair of conductive probes to determine when a predetermined liquid depth has been achieved upon detection of a resistive path through the liquid. Means may be provided for producing a signal representative of a

predetermined intermediate depth of liquid upon detection by means of the further probe and to maintain that signal when the level drops so as to maintain an intermediate operating speed for the motor.

In an advantageous refinement of the invention resistance change between said pair of probes between the level at which the liquid just touches the probes and the level at which the liquid just touches the further conductive probe is utilised to relate liquid depth to liquid conductivity. In one arrangement there is provided means coupled with said pair of conductive probes for deriving an electrical signal which is a function of the resistance between the probes, means for storing the amplitude of that signal when the liquid level rises to just touch the probe, means for storing the amplitude of that signal when the liquid level rises to just touch the shorter probe and means for calibrating the control signal within defined limits in dependence upon the two stored signals to adapt the control signal to the conductivity of liquid thereby to provide a substantially full pumping control range irrespective of conductivity of the liquid. In one configuration there is provided a resistor coupled in series with the pair of conductive probes, a pair of input lines for connection to a source of alternating current for feeding the series arrangement, an amplifier having an input fed by the voltage developed across the resistor, and a resistor to provide a d.c. analogue voltage output which is related to liquid depth. In a further refinement the

analogue voltage output is fed to an analogue to digital converter, the two signal values are stored in digital form and are compared by a computer which provides a control signal which is adapted to the conductivity of the liquid.

Alternatively, the level sensing means may comprise several liquid detectors arranged to detect the presence of liquid each at a different level in the container. The liquid detectors may be formed by float switches. Means may be provided for producing a signal representative of a predetermined intermediate depth of liquid upon detection by an intermediate one of the liquid detectors, and to maintain that signal when the level drops so as to maintain an intermediate operating speed of the motor.

The system may comprise a liquid falling level detector responsive to the control signal and operable to shut down the pump if a fall in liquid level does not occur within a predetermined time interval from switch on.

The invention also includes a milking machine comprising a liquid level control system, as previously defined, wherein the container is a milk receiving tank, a vacuum pump is coupled to the tank and is operative to induce milk into the tank from milk cups for attachment to cows and the pump coupled with the tank outlet is coupled with a bulk milk storage tank. The coupling between the tank outlet and the bulk storage tank may be provided with a heat exchanger to effect cooling of the milk. The bulk milk

storage tank may be refrigerated.

In order that the invention and its various other preferred features may be understood more easily, some embodiments thereof will now be described, by way of example only, with reference to the drawings, in which:-

Figure 1 is a simplified schematic illustration of a liquid level control system constructed in accordance with the invention,

Figure 2 is a schematic illustration of a receiving container provided with a three probe liquid level sensing arrangement usable in the construction of Figure 1,

Figure 3 is a schematic illustration of a receiver container having a range of liquid detectors arranged at different container depths to provide an alternative liquid level sensing arrangement useable in the construction of Figure 1,

Figure 4 is a block schematic illustration showing a possible configuration of control signal generator coupled with the liquid level sensing arrangement of Figure 2,

Figure 5 is a block schematic illustration showing an alternative configuration of control signal generator coupled with the liquid level sensing arrangement of Figure 3,

Figure 6 is a schematic circuit diagram of a refinement of part of the liquid level sensing system of the invention,

Figure 7 is a schematic illustration of a milking machine incorporating the principles of the invention and

Figure 8 illustrates schematically the operation of the arrangement of Figure 7 in the automatic milk pumping mode of operation.

In the drawings similar components are given the same reference numerals.

Referring now to Figure 1 a container formed by a tank 10 is supplied with a liquid via an input pipe 12. A level sensor arrangement 14 extends through the top of the tank towards the bottom and is connected to a control signal generator 16 which is coupled to a variable speed pump 18. An outlet 20 from the bottom of the tank is connected to the input of the pump 18 which serves to pump liquid out of the tank at a rate which increases as a function of liquid depth as controlled by the control signal generator in dependence upon the level sensor arrangement, as will be described in further detail in connection with Figures 4 and 5.

Figure 2 illustrates one form of the sensor arrangement 14 which is influenced by the depth of liquid in the tank 10. This comprises a pair of spaced conductive probes 22, 24 which extend downwardly into the tank in spaced apart side by side disposition. Alternatively the probes could be arranged to extend upwardly from the base of the tank. The electrical resistance between these probes will vary as a function of liquid depth and this resistance can be utilised to generate a control signal. An optional third probe 26 can be mounted alongside and spaced from the probes 22, 24 extending downwardly into the tank. The probe 26 is of length shorter than the probes 22, 24 and its

extremity is at an intermediate depth. The third probe can be utilised to determine when the liquid reaches the predetermined depth as there is a sudden change of electrical resistance between it and one of the probes 22, 24, once liquid reaches that level. The conductive level probe is a series of 3 stainless steel probes of equal length. One of the three probes is cut to equal one half of the total tank height plus 2 inches. (For example, if the tank is 24 inches deep, the probe would be cut at ½ of 24 inches plus 2 inches or 14 inches long). Trimming the probe to this level informs the system of the half way point in the tank. The extra 2 inches allows for a "buffer" zone at the top of the tank, ensuring the pump is at full speed prior to the tank overflowing and proper operation of any full tank alarms.

Figure 3 illustrates an alternative form of the sensor arrangement 14 in which the tank 10 is provided with several liquid detectors 28 mounted in the tank at different depths in the container and responsive only when liquid level rises to that depth or beyond. One suitable form of detector is a float-actuated switch. In a preferred form the float level switches are logic. Extra Low Voltage, (ELV), signal inputs which connect to a stack of three float switches. The float switches should be dry contact, normally open switches, which close in the presence of fluid.

Figures 2 & 3 are just two of many possible sensing systems influenced by changing liquid depth and any

form of sensing system which provides such information can be utilised within the scope of this invention for example a rheostat operated by a float valve, an optical beam generator and detector the path of which beam to the detector is diverted in the presence of a liquid.

The output or outputs from the liquid level sensor are coupled to the control generator 16 of Figure 1 which generates a signal which varies in dependence thereon and which is suitable for varying the rate of delivery of the variable speed pump. The pump is preferably driven by an electric motor and the control signal generator may generate a voltage or current which varies in amplitude and/or frequency as a function of depth. In the case of the sensor illustrated in Figure 3 the amplitude and/or frequency can be varied in a step wise fashion as each float switch is actuated or the change can be integrated to provide a gradual change in amplitude and or frequency between steps or the outputs from each sensor can form one input for a digital to analogue converter.

It will be appreciated that alternative ways of controlling the delivery from a pump are possible and can be utilised in this invention. For example a pump device driven at constant speed in which the displacement is controlled as a function of the control signal or having a throttle valve which provides a restriction which is a function of the control signal.

Referring now to Figure 4 there is illustrated in simplified schematic form a possible configuration of the

control signal generator utilising the liquid level sensor of Figure 2. A proportional level sensor 30 has two inputs each coupled to a different one of the longer probes 22, 24. A voltage is generated by the sensor which is dependent upon the resistance between the two probes by for example connecting a high impedance current source across the terminals. The voltage developed by the current source is arranged to vary between 0 & V between empty and full depth in the tank. The output from the sensor 30 is coupled to a maximum voltage detector 32. An intermediate level sensor 34 has one input coupled to one of the long probes 24 and another input coupled to the short probe 26. The resistance between the probes is very high in the absence of a liquid depth which bridges the probes but drops significantly when the liquid level rises to the level of the short probe. This resistance is utilised to provide a voltage which steps between substantially 0 and ½V by for example connecting a resistance connection in series with a high impendence current source across the terminals and utilising the step in voltage to trigger a switch coupled between the output and a source of voltage ½V. The output is coupled to a second input of the maximum voltage detector 32. The output of the proportional level sensor is coupled to a fall detector 36 which is also coupled to an on/off switch 38. The fall detector is triggered at switch on and if it detects a falling voltage level within a predetermined time interval it provides an output control signal to a latch 40 connected to the output of the maximum voltage detector 32

the purpose of which will be further described. The on off switch is connected to a timer 42. The timer provides an output voltage of V for a predetermined time interval from switch on of the switch 38 which voltage V is coupled to an input of the maximum voltage detector and also to the latch 40. When the system is switched on the timer 42 is triggered and actuates the latch 40 which connects the output of the maximum voltage generator 32 to the output 44. The timer also provides a voltage V to the maximum voltage detector 32 such that V appears at the output 44. This voltage causes the pump 18 to be run at maximum speed. The switch 38 also triggers the fall detector which determines whether the proportional level sensor 30 is detecting a fall in liquid level in the tank which shows that the pump has primed and is operating correctly. If this is the case then the detector provides a retaining signal which holds the latch on until the system is switched off. If no such signal is provided the latch drops out when the time period of timer 42 expires and the pump is shut down until the switch 38 is switched off and then on again. Provided that a fall in level is detected the pump continues to operate and provide a flow rate which is a function of the voltage at the output 44. If the level of liquid is greater than the intermediate depth then the proportional level sensor provides the highest voltage to the maximum voltage detector and this voltage is routed to the output 44 and the pump speed is varied as a function of changing depth. If the level drops below the intermediate level then the

intermediate sensor provides the highest voltage which is fixed at ½V and the pump speed is maintained at a fixed low speed.

Referring now to Figure 5 there is illustrated a control signal generator similar to that of Figure 4 but utilising the alternative liquid level sensor of Figure 3. In this arrangement the liquid detectors 28 are connected to different inputs of a proportional level sensor 44, which provides variable output voltage increasing in dependence upon depth, and an intermediate one of the detectors 28 is connected to the intermediate level sensor 45 to trigger an output voltage of ½V if the liquid does not reach the level to actuate that sensor. The output signals are coupled to the remaining blocks which operate in a manner similar to that described in connection with Figure 4.

The pump in the previously described embodiments can be an impeller pump and may have a flexible impeller. Such a pump is preferably driven by an AC induction motor fed by an inverter which provides a supply voltage and frequency which is dependent upon the control signal received from the output 42. In a particularly advantageous embodiment the induction motor is powered by a power supply having an inverter and as described in U.S. Patent Application Number 08/291,239 of the present inventor filed 16 August 1994, the whole contents of which is incorporated herein by reference.

In a particularly advantageous refinement of the invention the "half height" probe is utilised to determine

an X/Y graph, in software, of the relationship between the probes immersion in the liquid and the conductivity of the liquid. As a fluid becomes more conductive, a smaller amount of fluid is required to cause a proportional signal equal to that of a less conductive fluid. If a control microcomputer reads the conductivity value between the two long probes at the exact moment in time that fluid reaches the half height probe, a reference conductivity value can be determined. This allows proportional liquid level reading to be carried out over the entire length of the probe. For example, if the reference point for half height conductivity was fixed at say 50 ohms, a fluid with conductivity greater than 50 ohms would actually reach the half height point in the tank earlier, than the "real" half height point. Likewise, fluid with less conductivity would have the reverse problem. In an uncompensated system, only fluids with a conductivity exactly equal to a specific reference value would track the proportional level in accordance with the actual physical level. It can thus be determined that if the half point is not a fixed value but rather a variable data, then the control software could be arranged to adjust the value by reading the actual data when fluid physically touched the half height probe. This allows the system to be adaptive to varying conductivity of fluid entering the receiver system.

Referring now to Figure 6 one method of implementing the refinement is illustrated. A transformer, 50 generates an alternating, safety-isolated low voltage which is connected across the two long sensing probes 22,

24. A 1 ohm resistor 52 is inserted in one leg of the transformer-probe circuit. As the probes are immersed in liquid a minute voltage is developed across resistor 52 which is proportional to depth of immersion and liquid conductivity. An amplifier 54 amplifies the developed voltage and feeds it via a rectifier circuit 56 to an analog to digital converter 58. The analog to digital converter converts the amplified, proportional voltage to an 8 bit numeric equivalent which is read by a microcomputer device 60. The half height probe 26 is connected to a buffer amplifier 62 which provides a digital output change of state when liquid touches the probe. This signal is also rerouted to microcomputer 60.

SOFTWARE AND CONTROL OPERATION:

As previously described, the voltage developed across resistor 52 is dependent on the depth of immersion of the probes in liquid and the conductivity of the liquid. Assuming the receiver tank is empty, there will be no voltage across resistor 52 and the computer 60 will read a "null" output from the A/D converter. (Likewise) the half height probe will also signal no liquid to the microcomputer 60. When liquid just touches the bottom of the two long probes, a voltage is developed across resistor 52, is amplified by the amplifier 54 and is converted by the A/D converter 58 and read by the microcomputer 60. This value is stored in memory as the "lower" point on an X/Y graph which will be more fully described. As liquid level increases in the receiver tank, the developed voltage across resistor 52

increases in linear proportion. When the liquid just touches the half height probe, amplifier/buffer 62 changes state and the microcomputer is "notified" that the liquid level is now half way up the sensor probes 22, 24. Immediately, the microcomputer reads the developed voltage across resistor 52, via the amplifier 54 and A/D converter 58 as previously described. This second reading is stored as the upper point on an X/Y graph. It can now be seen that a liquid with higher conductivity will produce values for the "lower" and "upper" data points, greater than those of the first liquid. Similarly, a liquid with a lesser conductivity will produce data values less than the first liquid. Regardless of liquid conductivity, the relationship between depth of probe immersion and conductivity is a linear function. Therefore, if the "lower" data point reading is considered the "zero" point on the probe and the "upper" data point the half height of the probe then all other physical points on the probe can be calculated. For example, if the lower reading is 20 units, the upper, (50% depth), reading is 60 then 100% immersion would be a reading of 100 units. The relationship of probe immersion to pump speed may be software "coded" into memory and the appropriate output signals from the microcomputer, 60 are fed to the INVERTER SPEED CONTROL OUTPUT.

A milking machine employing the principles of the invention and based on the arrangements previously described is illustrated schematically in Figure 7. A milk receiver tank 10 has an input pipe 12 which is connected to a series

of milk cups 70 for coupling to the udder of one or more cows. The tank is closed and a vacuum pump 72 creates in the tank a suction which induces flow of milk from the milk cups 70 into the tank. The tank includes a liquid level sensor arrangement 14 which is of the form illustrated in Figure 2 but which can be of the form illustrated and described in connection with Figure 3. From the bottom of the tank an outlet 20 is coupled via a pump 74, which is preferably an ITT Jabsco Food grade flexible impeller pump, via a heat exchanger 76 to a refrigerated bulk milk storage tank 70. The heat exchanger is supplied with a through flow of cooling water via inlet 80 and outlet 82. The pump is driven by a 3 phase 4 pole AC induction motor 84, the speed of the motor is controlled by a power supply 86 having an inverter as described in US Patent Application Number 08/291,239 and provided with a mains input 88 for a source of single or three phase power or US 2 phase 220 volt power. The power supply is controlled in dependence upon the milk level sensed in the tank 10 in the manner previously described in relation to Figures 1 to 6. A sensor also activates a high milk level alarm 92.

The operation of the system is as follows:-

1. The system is started by actuation of an ON/OFF switch (not illustrated in Figure 7).

2. The pump remains off until milk reaches the shortest probe at the tank 1/2 level. When milk reaches this point, the pump will start on high speed for a maximum period of 20 seconds.

3. During the 20 second priming sequence. The system monitors the milk level in the receiver tank. If the level drops during priming, the prime sequence is complete and control passes to step 4. If the fluid level does not drop during the priming sequence, the prime fails. During priming, the flexible impeller pump running on high speed should be able to remove milk faster than the rate at which it enters the receiver tank. If this does not happen, a failure is assumed and the pump is shut off.

The user may repeat the priming sequence by switching off and on again.

Repeated priming failures may indicate leaking plumbing between the milk receiver tank and pump or a defective pump. (Also note that successful priming does not necessarily indicate that the pump is primed. If air is displaced from the intake lines by pump suction, milk level in the receiver tank will drop. Depending on pipe size and distance between receiver and tank, suction flooding may take additional time).

4. The pump speed will remain at low speed when milk is between the bottom and ½ height of the receiver tank. When milk level is between ½ height and the tank "virtual full" level, the pump will "track" the milk level detected by the probes in the receiver tank. (When the tank is

full), the pump will run at maximum speed of 50 hertz. As the tank level drops, .pump speed will drop to a minimum speed of 20 hertz. There are 32 discrete inverter speeds divided over ½ the total length of the probe.

5. Should the receiver tank empty when in the auto run mode, the pump will stop. This can be arranged by actuation of the lowest sensor or by the step change in resistance which occurs when liquid drops below the level of the two longer probes.

Notes/

a. Moving the toggle switch to the STOP position will immediately stop the pump.

b. If float switches are utilized, instead of conductive probes, operation remains the same as described except that the speed changes are synthesized as the float switches become covered/uncovered.

c. The diagram of Figure 8 illustrated schematically the operation in the automatic milk pumping mode of operation.

The system described provides the following advantages:-

1. GENTLE ACTION - Manufacture of certain dairy products, e.g. Dutch-style cheeses requires milk with a low level of free fatty acids (FFA's). High speed centrifugal pumps break open the fat

globules allowing enzymes to attach the fat and create these acids, so a low speed gentle action pump is desirable.

2. HIGH LEVEL MOUNTING - A Milking parlour is a very wet and dirty place. Centrifugal pumps mounted near to floor level in the pit are at risk from pressure washdown jets and are prone to mechanical damage. Milk pipelines are often run at ground level as high levels and vertical drops can increases FFA's - this prevents the receiver form being raised. As a result, a pump which can be mounted above the receiver is desirable, i.e. self-priming.

3. EASILY-CLEANED-IN-PLACE - The diaphragm type pumps are difficult to clean due to the presence of valves in the milk flow. Also effective cleaning demands high cleaning fluid flow rates which may be higher than the normal milk flow. A pump which is inherently CIP-able and which generates high flows is advantageous.

4. ABLE_TO DISPLACE FROTH - Centrifugals are prone to air locking when froth enters. A positive displacement pump is desirable to keep the milking process operating without interruptions for venting or even a service call out.

5. UNDAMAGED BY SOLIDS - Occasionally small stones enter the system, picked up from the teats

or off the floor when the cluster is removed. Lobe pumps have been tried in milk parlours but are easily jammed; a jam free pump is desirable.

6. SIMPLE - Diaphragm pumps have many moving parts, both within and outside the milk wetted area. Dairy farmers want a simple, easy to service pump.

7. EFFICIENT COOLING -Milk commonly passes through a water plate cooler before reaching the bulk tank. A cost saving to the farmer results if the milk passes as slowly and steadily as possible through the cooler (less water and less refrigeration). A two or variable speed pump allows efficient cooling of milk and high wash-water flow.

8. RELIABLE - High speed Centrifugals suffer from short seal life, diaphragms are expensive to replace and can last only half or a third of a season. A pump with long component life and low cost spares is desirable.

Whilst the embodiments described all relate to the pumping of milk it will be appreciated that the Principles of this invention are applicable to level sensing and pumping of any conductive liquid e.g. water.

CLAIMS:

1. A liquid level control system, comprising a container for receiving a flow of liquid, level sensing means for providing a control signal variable in dependence upon the depth of liquid in the container a pump coupled with an outlet from the container and responsive to the control signal for expelling liquid from the container at a rate which varies as a function of the liquid depth.

2. A sensor as claimed in claim 1, wherein the pump is an impeller pump.

3. A system as claimed in claim 2, wherein the pump has a flexible impeller.

4. A system as claimed in any one of the preceding claims, wherein the pump is driven by an electric motor at a speed which is variable in dependence upon the control signal to vary the rate at which liquid is expelled.

5. A system as claimed in claim 4, wherein the electric motor is an AC induction motor.

6. A system as claimed in claim 5, wherein the induction motor is powered by an inverter which provides a supply voltage and frequency, dependent upon the control signal, which is a function of liquid depth.

7. A system as claimed in claim 6, wherein the induction motor is powered by a power supply having an inverter and as described and claimed in US Patent Application Number 08/291,239.

8. A system as claimed in any one of claims 4 to 7, comprising means for providing a control signal at switch on to run the motor at high speed for a predetermined time interval thereby to prime the pump.

9. A system as claimed in any one of claims 4 to 8, wherein the level sensing means comprises a pair of spaced conductive probes extending downwardly or upwardly side by side in the container and wherein the resistance between the probes which varies as a function of liquid depth is employed to provide the control signal.

10. A system as claimed in claim 9, wherein a further conductive probe of length shorter than said pair of conductive probes is provided extending downwardly alongside the pair of conductive probes to determine when a predetermined liquid depth has been achieved upon detection of a resistive path through the liquid.

11. A system as claimed in claim 10, wherein means is provided for producing a signal representative of a predetermined intermediate depth of liquid upon detection by means of the further probe and to maintain that signal

when the level drops so as to maintain an intermediate operating speed for the motor.

12. A system as claimed in claim 10 or 11, wherein resistance change between said pair of probes between the level at which the liquid just touches the probes and the level at which the liquid just touches the further conductive probe is utilised to relate liquid depth to liquid conductivity.

13. A system as claimed in claim 12, comprising means coupled with said pair of conductive probes for deriving an electrical signal which is a function of the resistance between the probes, means for storing the amplitude of that signal when the liquid level rises to just touch the probe, means for storing the amplitude of that signal when the liquid level rises to just touch the shorter probe and means for calibrating the control signal within defined limits in dependence upon the two stored signals to adapt the control signal to the conductivity of liquid thereby to provide a substantially full pumping control range irrespective of conductivity of the liquid.

14 A system as claimed in claim 13, wherein the means for providing an electrical signal comprises a resistor coupled in series with the pair of conductive probes, a pair of input lines for connection to a source of alternating current for feeding the series arrangement, an

amplifier having an input fed by the voltage developed across the resistor, and a resistor to provide a d.c. analogue voltage output which is related to liquid depth.

15. A system as claimed in claim 14, wherein the analogue voltage output is fed to an analogue to digital converter, the two signal values are stored in digital form and are compared by a computer which provides a control signal which is adapted to the conductivity of the liquid.

16. A system as claimed in any one of claims 4 to 8, wherein the level sensing means comprises several liquid detectors arranged to detect the presence of liquid each at a different level in the container.

17. A system as claimed in claim 16, wherein the liquid detectors are formed by float actuated switches.

18. A system as claimed in claim 16 or 17, wherein means is provided for producing a signal representative of a predetermined intermediate depth of liquid upon detection by an intermediate one of the liquid detectors, and to maintain that signal when the level drops so as to maintain an intermediate operating speed of the motor.

19. A system as claimed in any one of the

preceding claims, comprising a liquid falling level detector responsive to the control signal and operable to shut down the pump if a fall in liquid level does not occur within a predetermined time interval from switch on.

20. A liquid level control system substantially as described herein with reference to the drawings.

21. A milking machine comprising a liquid level control system as claimed in any one of the preceding claims, wherein the container is a milk receiving tank, a vacuum pump is coupled to the tank and is operative to induce milk into the tank from milk cups for attachment to cows and the pump coupled with the tank outlet is coupled with a bulk milk storage tank.

22. A milking machine as claimed in claim 21, wherein the coupling between the tank outlet and the bulk storage tank is provided with a heat exchanger to effect cooling of the milk.

23. A milking machine as claimed in claim 21 or 22, wherein the bulk milk storage tank is refrigerated.

24. A milking machine substantially as described herein with reference to the drawings.

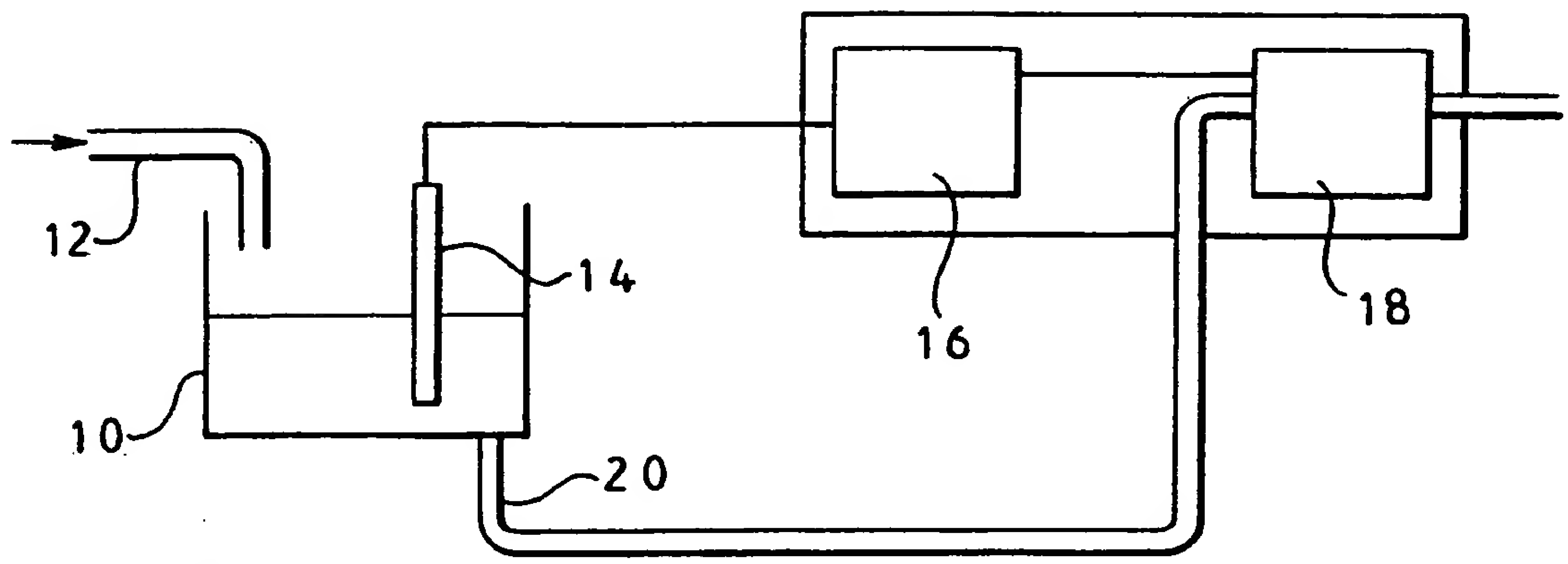


FIG 1

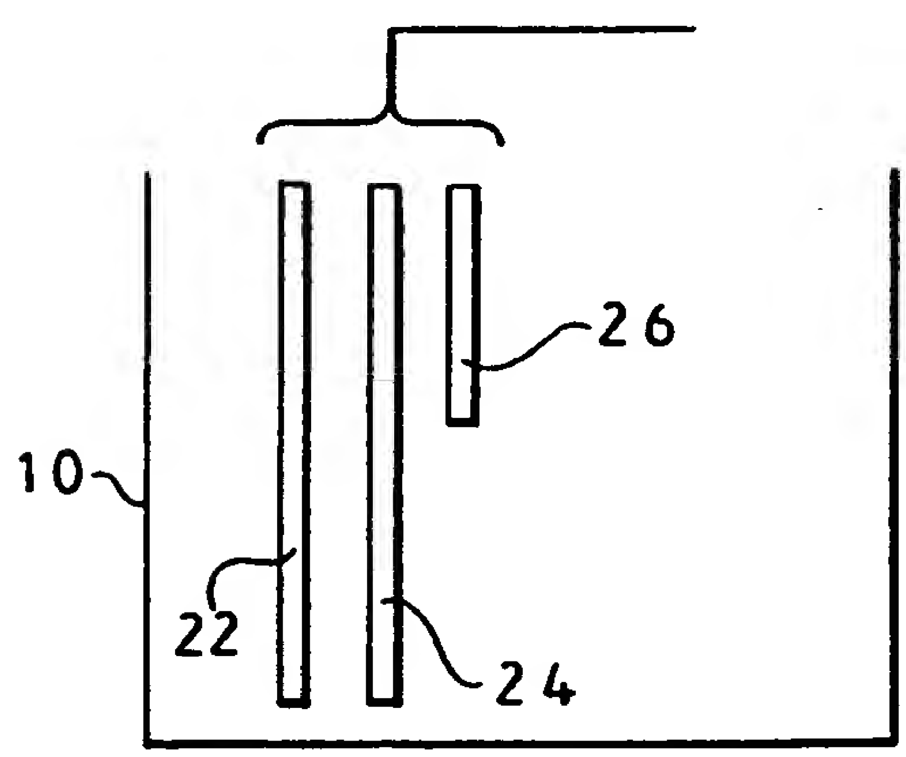


FIG 2

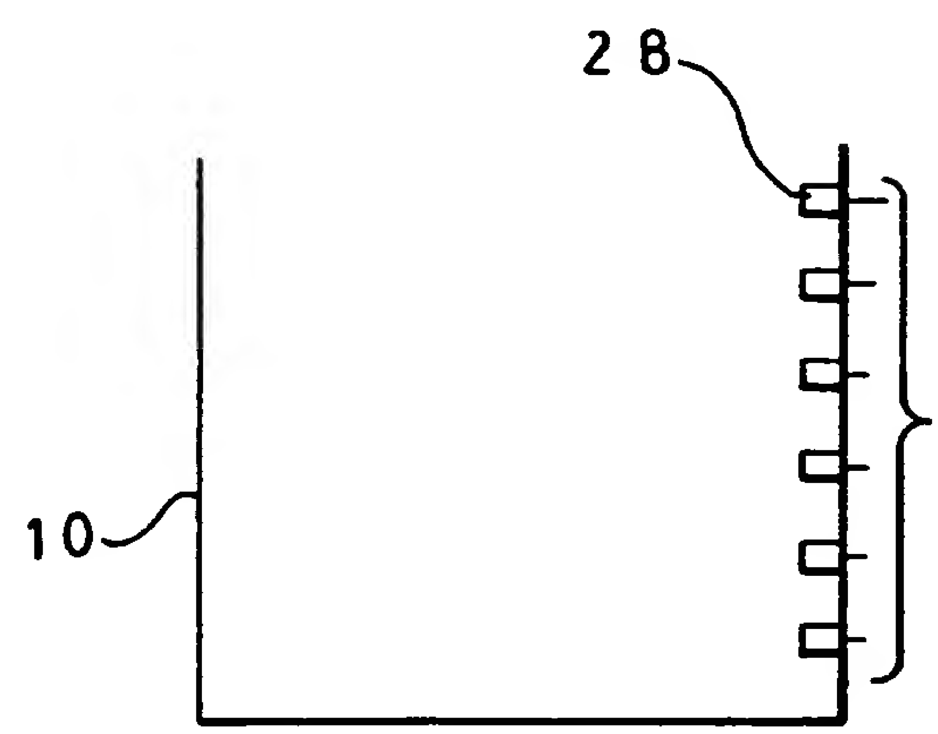


FIG 3

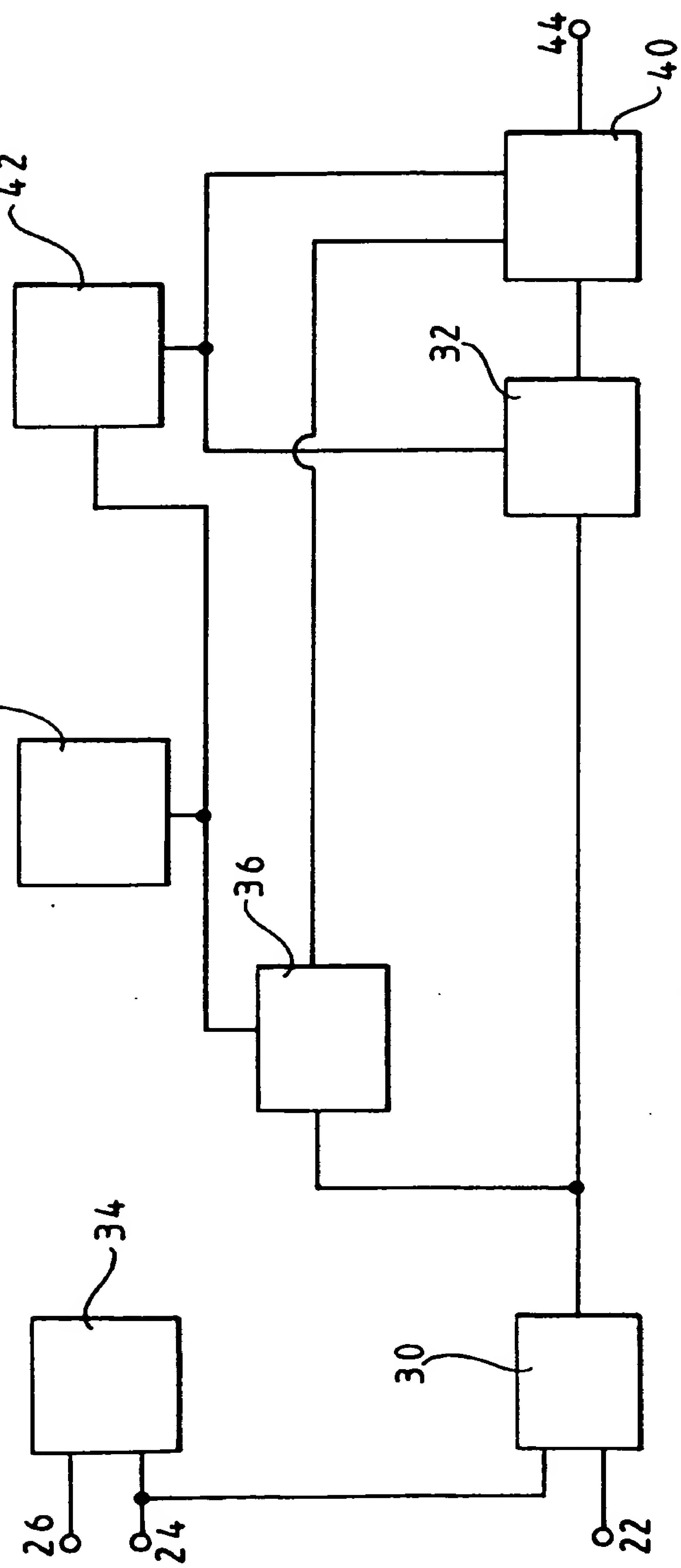


FIG 4

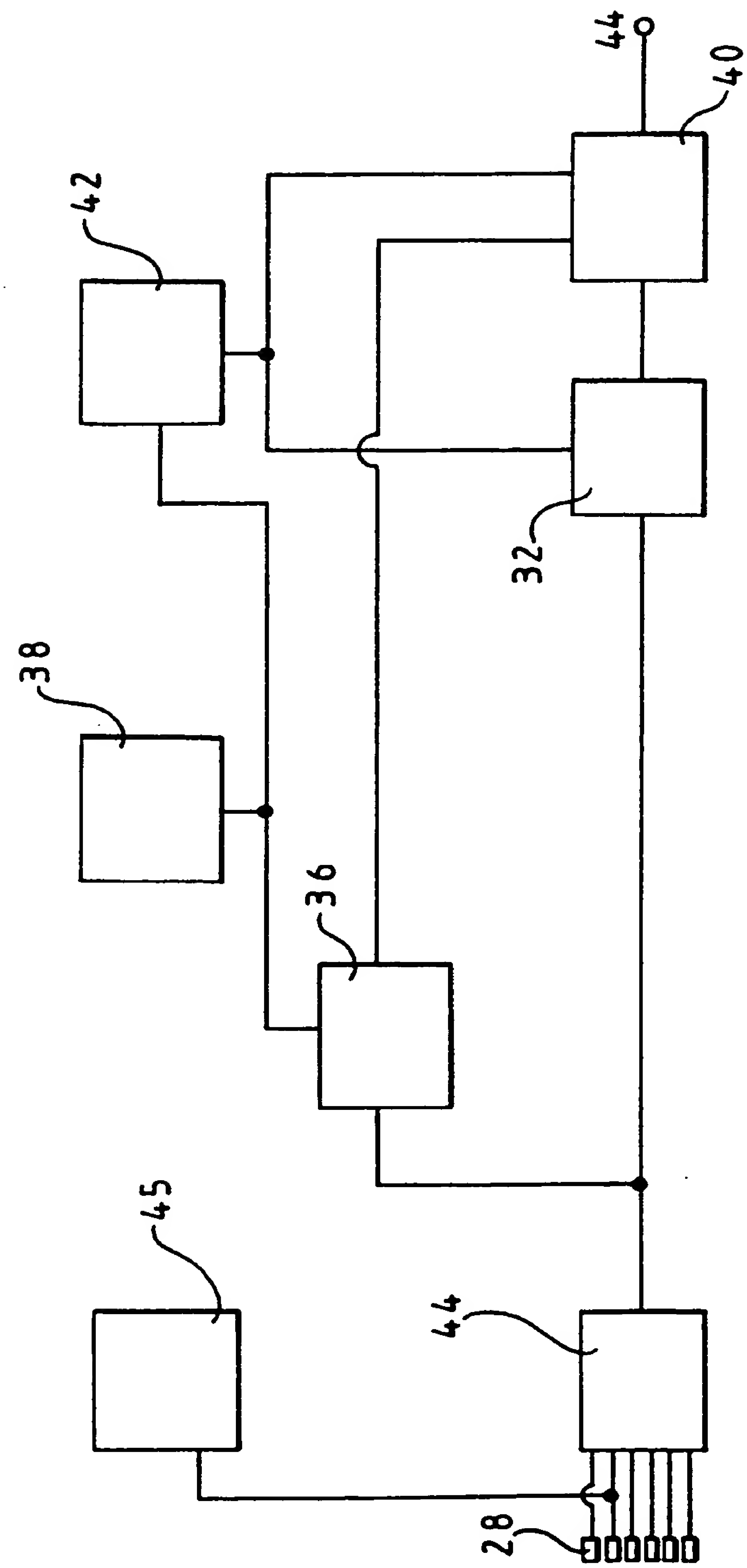


FIG 5

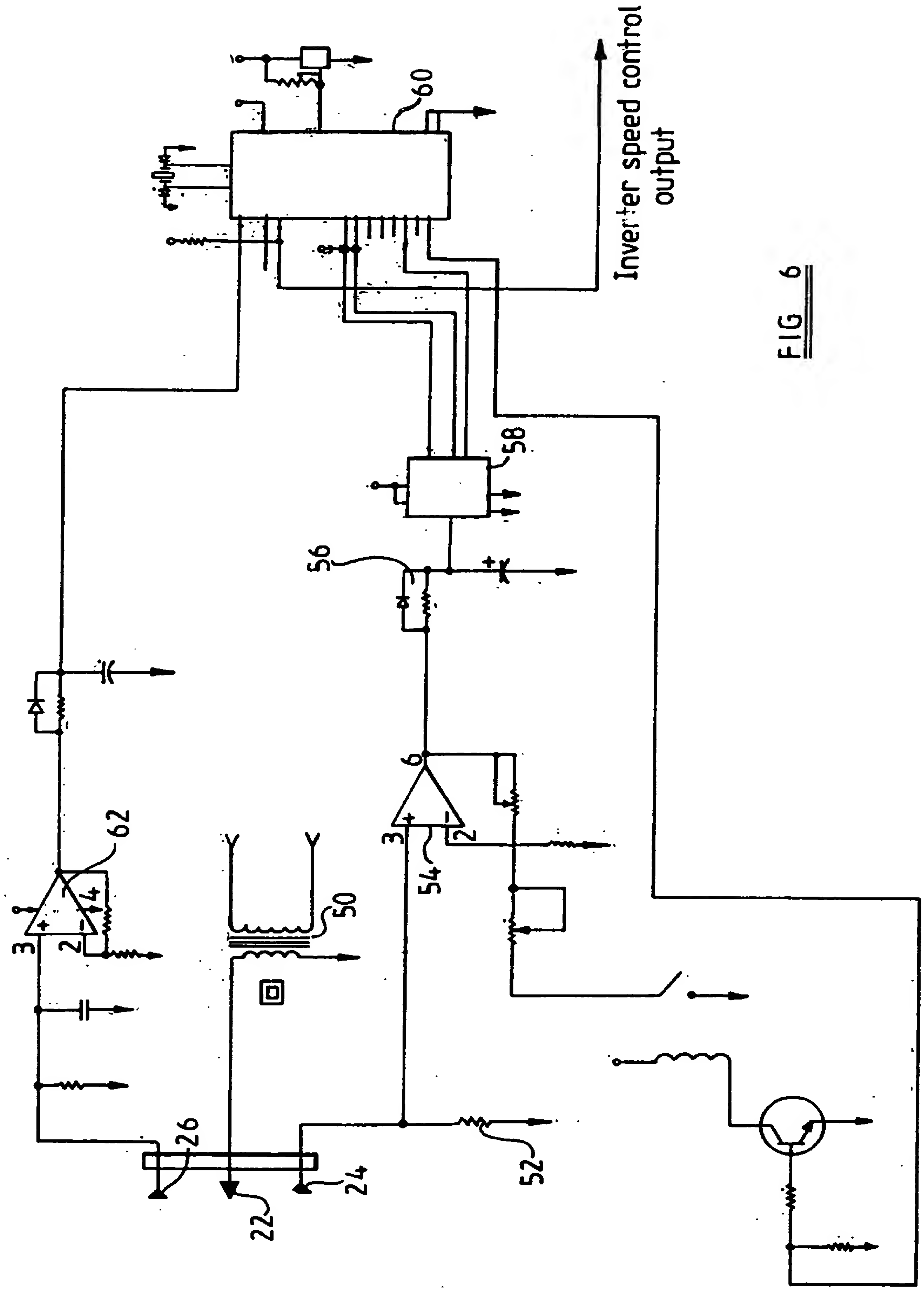


FIG 6

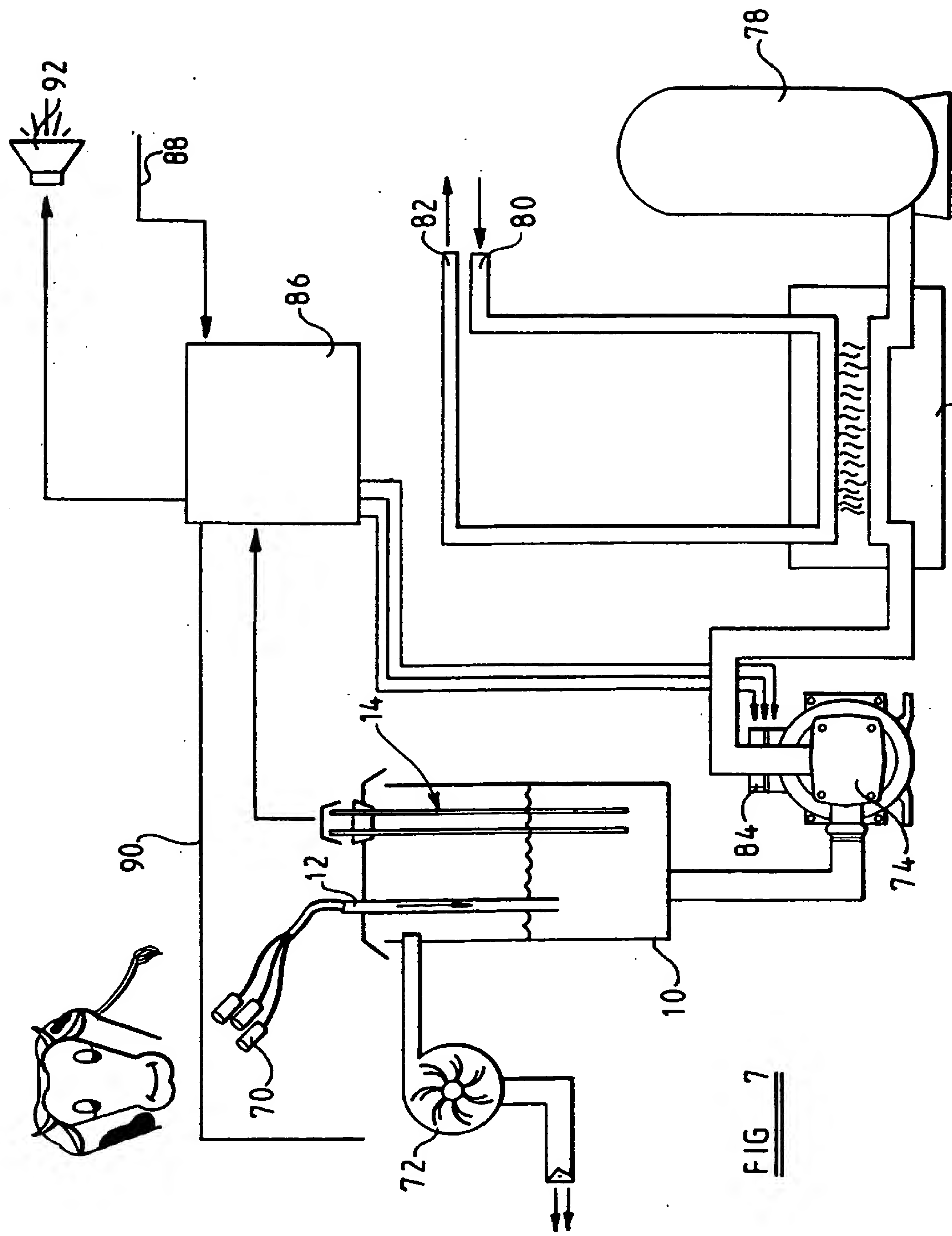
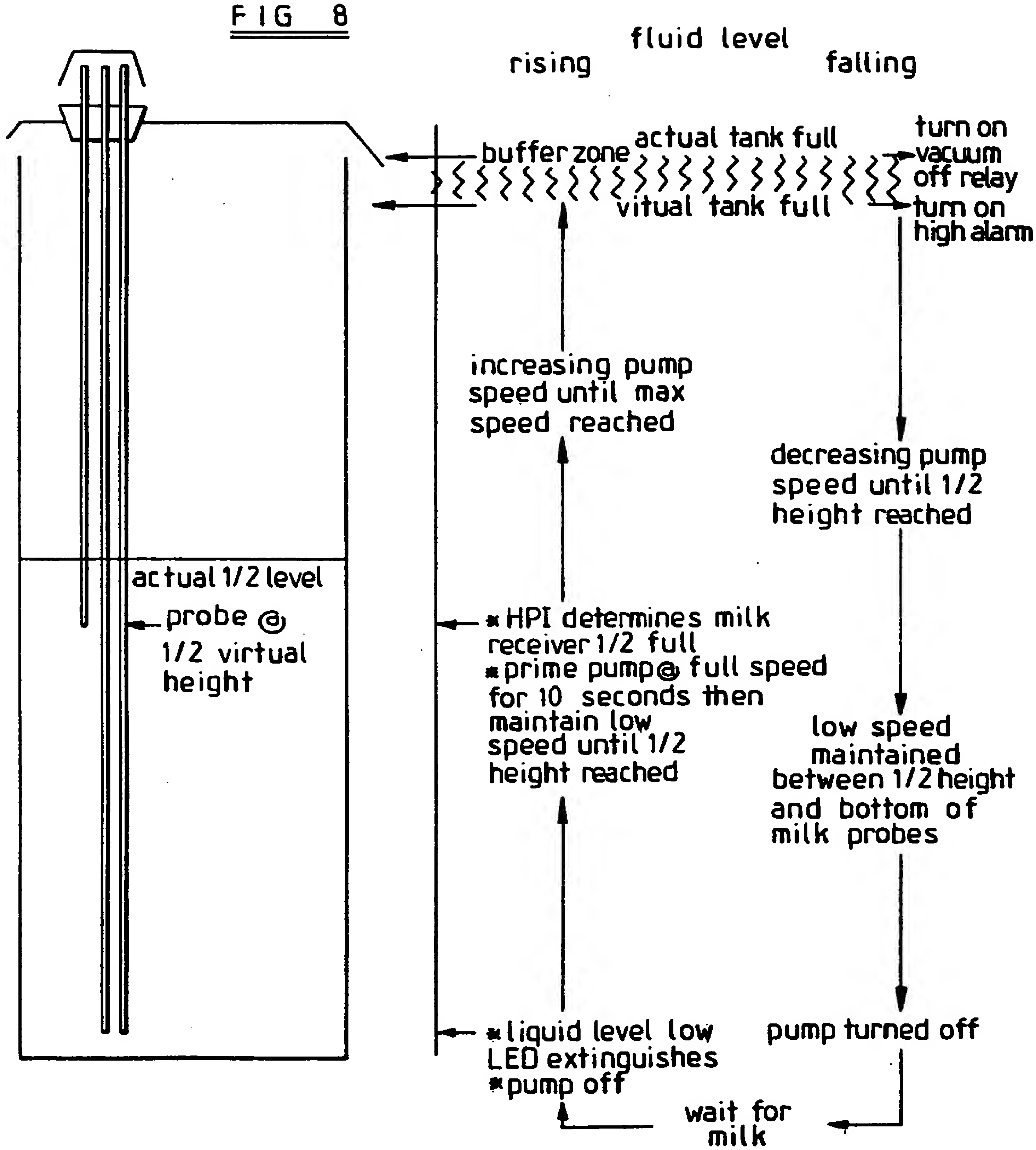


FIG 7

FIG 8


fluid level
rising
falling
actual tank full
buffer zone
vitual tank full
turn on vacuum off relay
turn on high alarm
increasing pump speed until max speed reached
decreasing pump speed until 1/2 height reached
actual 1/2 level
probe @ 1/2 virtual height
* HPI determines milk receiver 1/2 full
* prime pump @ full speed for 10 seconds then maintain low speed until 1/2 height reached
low speed maintained between 1/2 height and bottom of milk probes
* liquid level low LED extinguishes
* pump off
pump turned off
wait for milk

INTERNATIONAL SEARCH REPORT

Inte[rnatio]nal Application No
PCT/GB 96/01677

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G05D9/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 308 504 (KEYES WILFORD W) 3 May 1994 see the whole document ---	4,16
Y	US,A,4 095 920 (NEEDHAM LYLE L ET AL) 20 June 1978 see the whole document ---	21,24
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 104 (E-397), 19 April 1986 & JP,A,60 241781 (MITSUBISHI DENKI KK), 30 November 1985, see abstract ---	5
X	US,A,5 180 013 (ABDUL ABDUL S) 19 January 1993	1,20
Y	see the whole document --- -/--	2,4,16, 21,24

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
10 September 1996	24.09.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kelperis, K

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01677

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	NL,A,7 409 993 (DANSKE MEJERIERS MASKINFABRIK) 4 March 1975 see the whole document ---	2
A	DE,A,27 45 036 (STA RITE INDUSTRIES) 8 June 1978 see page 8, line 1 - page 9, line 8 ---	1
A	US,A,4 125 163 (FITZPATRICK DOUG) 14 November 1978 see the whole document ---	1
A	MEASUREMENT AND CONTROL, vol. 27, no. 7, September 1994, LONDON, pages 216-220, XP000468759 S.GRADY ET AL: "USE OF SIMULATION TOOLS FOR PUMP CONTROLLER DESIGN" see the whole document ---	6
P,X	WO,A,95 32817 (SANDOZ) 7 December 1995 see claims 1-5 -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 96/01677

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-5308504	03-05-94	NONE		
US-A-4095920	20-06-78	CA-A-	1065440	30-10-79
US-A-5180013	19-01-93	US-A-	5341877	30-08-94
NL-A-7409993	04-03-75	CH-A-	577633	15-07-76
		FR-A-	2242580	28-03-75
		GB-A-	1481423	27-07-77
		SE-B-	393442	09-05-77
		SE-A-	7411008	03-03-75
DE-A-2745036	08-06-78	US-A-	4105367	08-08-78
		AU-B-	512898	06-11-80
		AU-A-	2994177	26-04-79
		CA-A-	1073541	11-03-80
		FR-A-	2368079	12-05-78
		GB-A-	1572221	30-07-80
US-A-4125163	14-11-78	NONE		
WO-A-9532817	07-12-95	AU-A-	2673195	21-12-95